Geophysical investigation of methane seeps on the NE Sakhalin continental slope, Sea of Okhotsk

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오호츠크해 북동사할린 대륙사면에 나타나는 메탄분출구에 대한 지구물리탐사

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Abstract: During CHAOS (2003, 2006) and SSGH projects (2007), acoustic investigation including hydroacoustic (HA), side-scan sonar (SSS) and high-resolution sparker seismic (HSS) surveys was carried out on the northeastern Sakhalin slope (53°56' N, 143°52' E to 54°40' N, 144°32' E). More than 130 methane seeps with high backscatter intensity are identified on SSS mosaic, which are well accompanied with gas flares in the water column on HA profiles and sub-bottom gas chimneys on HSS profiles. It is likely that that some seeps align along a NW strike parallel to the Lavrentiev Fault.
Keywords : gas hydrate, acoustic, methane seep, gas flare, gas chimney

요약: 2003년, 2006년과 2007년, 사할린 북동사면 53°56' N, 143°52' E to 54°40' N, 144°32' E 지역에서 음향측심, side-scan sonar (SSS), 고해상도 스파커 탄성파 탐사를 포함한 다양한 주파수 대역의 음향탐사를 실시하였다. 높은 후방산란강도를 가진 약 130여 개의 메탄분출구들이 해저면에 발달해 있는 SSS 영상도를 획득하였다. 음향측심탐사에서의 수층 가스분출구조와 탄성파탐사에서의 해저지층 가스기둥구조들이 이 해저면 구조들과 잘 부합하여 나타난다. 이런 메탄분출구조들은 북서 주향을 갖는 Lavrentiev 단층과 평행한 구조선을 따라 배열하는 것처럼 보인다.
Keywords : 가스하이드레이트, 음향, 메탄분출구, 수층가스분출구조, 지층가스기둥구조

1. Introduction

Gas hydrate is a substance which resembles ice and contains methane and other gases with low molecular weight in the water lattice (Sloan, 1998). Methane hydrates are stable under temperatures and pressures existing in regions with permafrost and on passive and active continental margins at sea depths more than 300-500 m.

Gas and water fluids seepage through sediments and their effusion onto bottom

surface may be to some extent connected with gas hydrates. It is supposed, that it may occur due to gas hydrates disintegration at the bottom of their stability zone (300–600 m below sea bottom surface) caused by change in P–T conditions (Max et al., 2006).

One of such regions with wide spread occurrence of gas hydrates and intensive gas seepages is located on the northeastern Sakhalin continental slope (the Okhotsk Sea) (Shoji et al., 2005). In this study, we examine distribution and characteristics of gas seepages occurring in gas hydrate stability zone the slope.

2. Data acquisition

During CHAOS (2003, 2006) and SSGH projects (2007), sparker seismic, hydro-acoustic, and deep towed side-scan sonar surveys were carried out simultaneously along the same survey tracks. The seismic data were obtained using a sparker system ' SONIC-4' made in Russia. Sparker was operated as a source with the frequency range of 200-1200 Hz and the energy of 500-2000 J, and single channel streamer was used as a receiver. To detect acoustic expressions of gas emission sources into the water column, the level of acoustic backscattering was collected simultaneously using hydroacoustic system ' ELAC' with a frequency of 12, 20 kHz. Deep towed side-scan sonar images were collected using ' SONIC-3' system with a frequency of 30 kHz in a medium-range mode and a swath range of 800-3200 m. The ' SONIC-3' system is also equipped with a subbottom profiler operating at a frequency of 5 kHz.

3. Results

3.1. Hydroacoutic survey: Gas flares in the water column

By hydroacoustic surveys, a lot of gas flares in the water column were newly compiled. Some flares rose higher than 700 m meters from the seafloor to the sea surface (Fig. 1). Methane concentration in the water column dramatically increased near the bottom of the flare sites by several tens thousand times as much as background value. Some gas flares seem to sustain up to the sea surface above 300 m water depth that is expected to be the top of the gas hydrate stability zone in the study area.

3.2. Side scan-sonar (SSS) survey: Methane seepages in the seafloor

SSS surveys carried out during 2003, 2006, 2007 cruises enable us to map the bottom expressions with high back-scatter intensity which are considered as

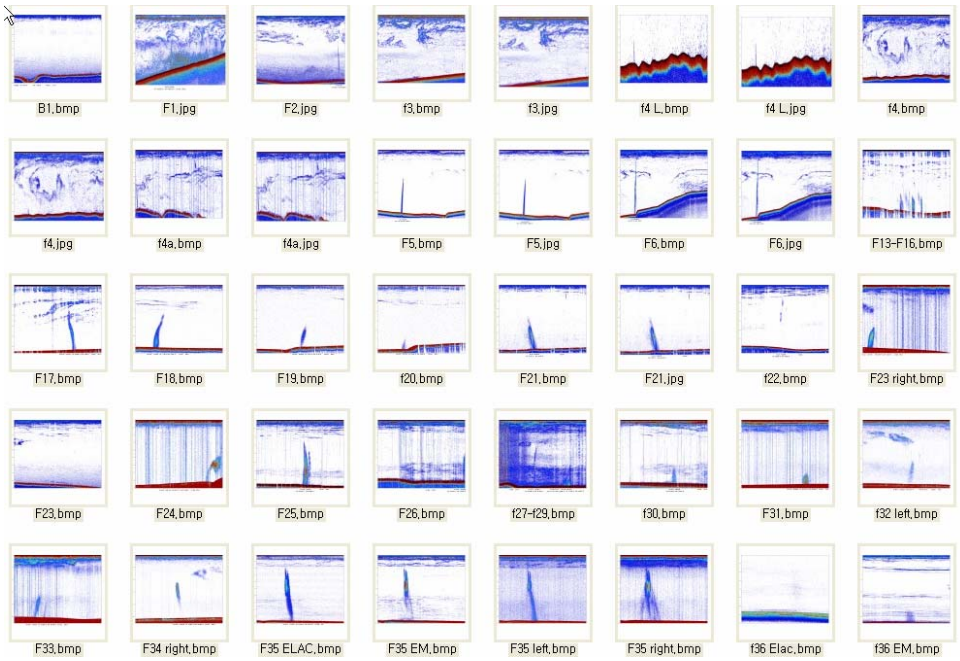

Fig. 1. Gas flares detected during hydroacoustic survey.

seepage structures (Fig. 2). Sonar survey covered slope area between 53º 57.5' N and 54º 40' N in depth interval 480–1075 meters. A total of 157 seepage structures were distinguished during the surveys.

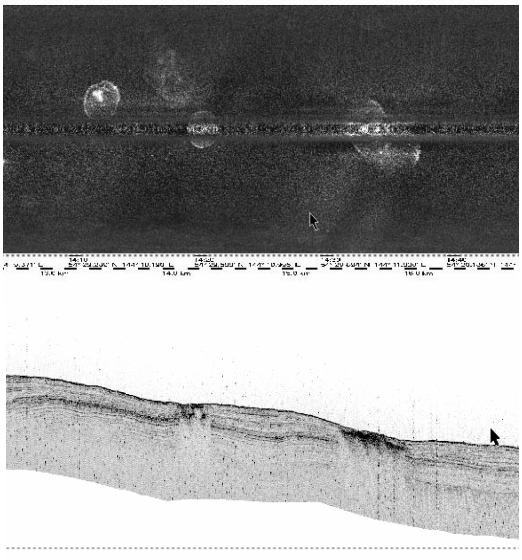

Fig. 2. SSS image (top) and subbottom profile (bottom) showing methane seeps.

3.3. Sparker seismic survey: Gas chimneys in the gas hydrate–baring sediments

High-resolution seismic profiles show many near-vertical structures penetrating through the gas-hydrate bearing sediments below seepage structures (Fig. 3). The chimneys seem to rise from the high amplitude reflections (HARs) and some of them reach to the seafloor. They are characterized by narrow (about 100~200 m in width) and confined white-colored wipeout (little or no coherently reflected seismic energy) chimneys on sparker seismic profiles.

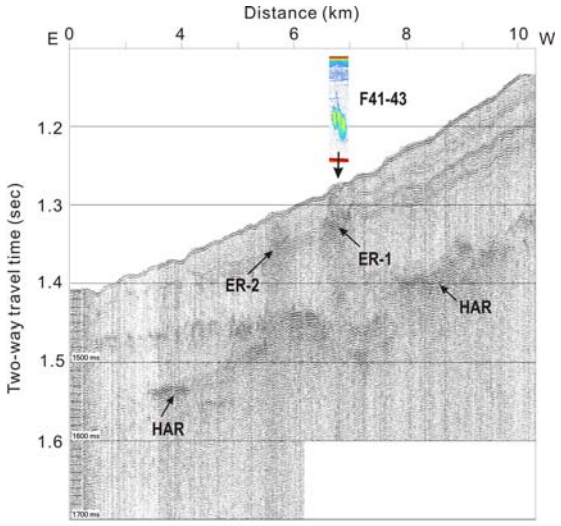

Fig. 3. Section of sparker seismic profile showing gas chimneys.

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